

BERKELEY
FREQUENCY METER

Model 5570

INDUSTRIAL AND NUCLEAR INSTRUMENTS

ANALOG COMPUTERS

Berkeley *division*

BECKMAN INSTRUMENTS, INC.
2200 WRIGHT AVE., RICHMOND, CALIF.



WARNING

**Do not attempt to operate this instrument
until you have read the Instruction Manual.**

INSTRUCTION
MANUAL

Lot 4 and up
Serial 211 and up

BERKELEY
FREQUENCY METER

Model 5570

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
15 February 1954

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

copyright 1953

Berkeley *Division*
BECKMAN INSTRUMENTS, INC.

Section 1	Introduction	1
	Description of Equipment	
	Specifications	
	Accessories	
Section 2	Operation	3
	Installation	
	Operation	
Section 3	Theory of Design	9
	Design	
	Heterodyne Unit	
	Indicator Unit	
	Time Base	
	Operation as a Pulse Counter	
	Power Supply	
Section 4	Maintenance	16
	Routine Service	
	Troubleshooting	
Section 5	Parts List	27
	Nonstandard Components	
	Tube Complement	
Appendix A	Instruction Manual, Model 705A	
Appendix B	Instruction Manual, Model 707A	

ILLUSTRATIONS

Figure 1	Model 5570 Frequency Meter	Frontispiece
Figure 2	Outline Front Panel, Model 5570	4
Figure 3	Functional Diagram, Model 5570	8
Figure 4	Functional Diagram, Heterodyne Unit	10
Figure 5	Functional Diagram, Indicator Unit	12
Figure 6	Typical Waveshapes, Model 5570	24
Figure 7	Schematic Diagram, Model 5570 Time Base	31
Figure 8	Schematic Diagram, Model 5570 Heterodyne Unit	33
Figure 9	Schematic Diagram, Model 5570 Indicator Unit	35
Figure 10	Schematic Diagram, Model 5570 Power Supply	37

Table 1	Control and Connector Functions	5
Table 2	Service Chart	18
Table 3	Troubleshooting Chart	20
Table 4	Voltages	22

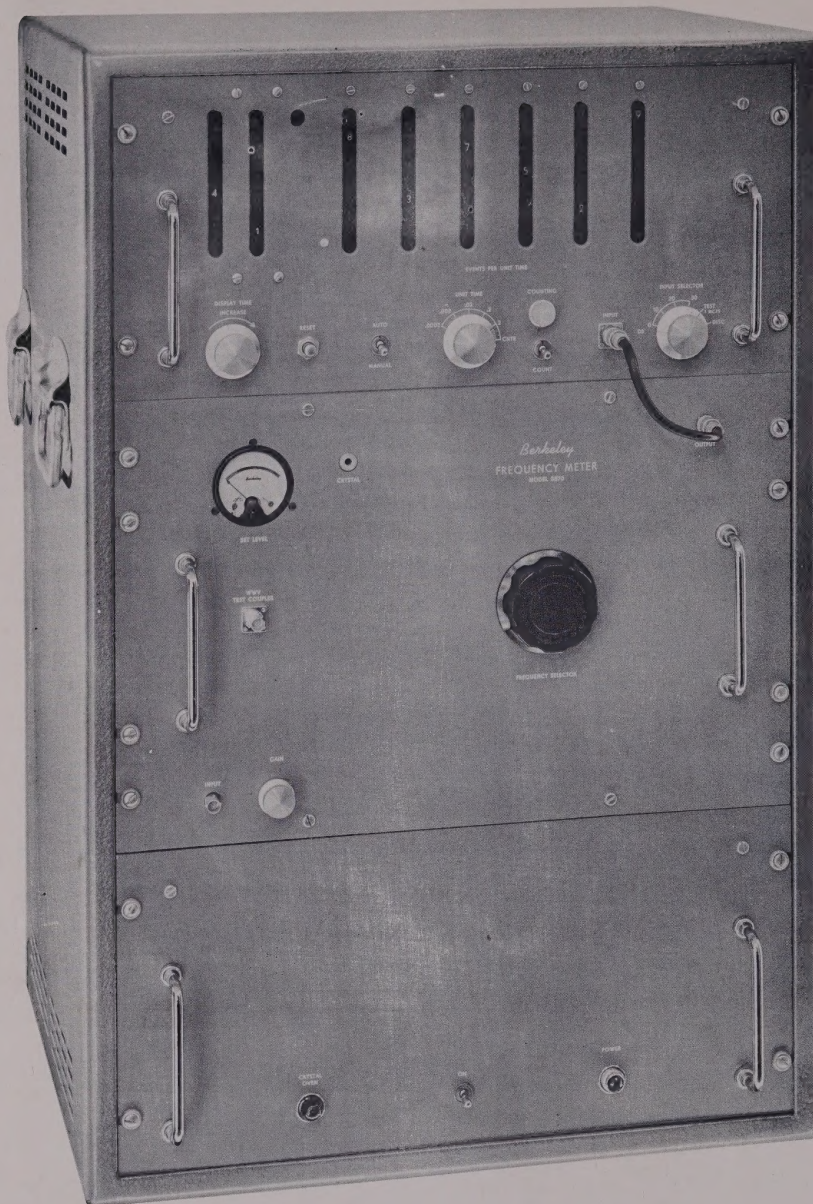


Figure 1 Model 5570 Frequency Meter

Section 1 INTRODUCTION

The Model 5570 Frequency Meter is designed to measure and present in digital form frequencies from 0 to 42 megacycle. Precise measurements, accurate to one part in ten million plus or minus one count, may be obtained with minimum effort.

Basically, the instrument consists of two sections, a crystal controlled Heterodyne unit and a high speed Events-Per-Unit-Time meter. Any unknown frequency may be applied to the Heterodyne unit, passed to the EPUT meter as a frequency of 1 megacycle or less, and displayed on the eight digit EPUT section.

The Heterodyne unit, composed of a 1 megacycle pulse generator and harmonic selector, a mixer, output amplifier, low pass filter, and output level meter, has a large rotary control on the front panel which is used to select any harmonic of one megacycle from 2 to 41 as a reference frequency.

Signals of less than 2 megacycles may be directly injected into the EPUT section. For higher frequencies, the signal is applied at the input jack of the Heterodyne unit where it is mixed with the reference frequency to produce a beat frequency which is applied to the counting circuits.

The EPUT section combines a high-speed electronic counter with an accurate crystal controlled time base. The time base opens and closes an electronic gate for a precise counting interval. This section will accept a maximum of 4,500,000 million pulses in a two second counting interval.

Through synchronization with WWV, the Model 5570 may be quickly and accurately adjusted even during an actual measurement. The overall accuracy is a function of the crystal stability plus the irreducible error of all electronic counting devices, $\pm$ one count.

Specifications

Range:	Zero to 42 megacycles/sec.
Accuracy:	± 1 count $\pm$ crystal error (short term: 1 part in 10^7)
Input Sensitivity:	Not more than 100 millivolts rms.

Input Impedance:	Standard - 100 ohms 100 K on request
Display Time:	1 to 5 seconds continuously variable
Sample Period:	2 seconds
Time Base:	0. 0002, 0. 002, 0. 02, 0. 2, 2. 0 seconds
Power Requirements:	117 volts a-c $\pm 10\%$ 50 to 60 cps at 400 watts
Accessory Sockets:	Connects to Digital Recorder System Coax input socket for use with external reference Coax output socket connects to VHF
Dimensions:	Indicator unit 8-3/4" x 19" x 16" Heterodyne Unit 12-3/4" x 19" x 11" Power Supply 8-3/4" x 19" x 16" Overall 32" x 21" x 19"
Weight:	165 pounds

Accessories

The Digital Recorder System may be used with the Model 5570 to provide a continuous printed record of frequencies measured. By this means, time consuming tests such as frequency vs. temperature may be performed automatically.

Higher frequencies, up to 150 megacycles, may be measured with the Model 5575 Converter. The Model 5575 is connected to the Model 5570 through a socket provided at the 1 megacycle crystal output. Converters capable of measuring up to 500 megacycles may be obtained on special order.

Section 2 OPERATION

Installation

The Model 5570 requires no special installation procedure. It may be operated in any well ventilated location. The unit is designed to operate from an a-c source of 117 volts, 50-60 cps, at a power rating of 400 watts. Satisfactory operation may be expected from 105 to 130 volts. The complete instrument consists of three units, Heterodyne, Indicator, and Power Supply.

The following interconnections should be visible from the rear of the cabinet:

1. Heterodyne unit to J105 on indicator unit
2. Heterodyne unit to J104 on indicator unit
3. J102 of indicator unit to J401 of heterodyne unit
4. Indicator unit to power supply unit
5. Fan (on cabinet) to indicator unit

Operation

To put the instrument in operation, connect the power cord and turn on the POWER switch (see Figure 2 and Table 1). After a five minute warm-up, test the instrument for proper operation:

1. Turn UNIT TIME switch to 2
2. INPUT SELECTOR to TEST 1 MC
3. AUTO/MANUAL switch in AUTO position

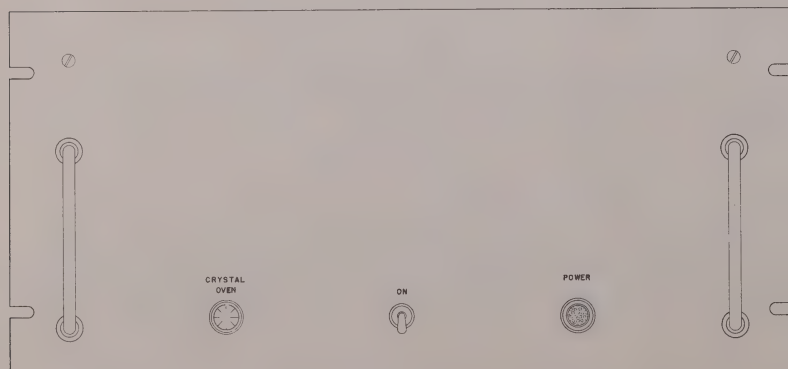
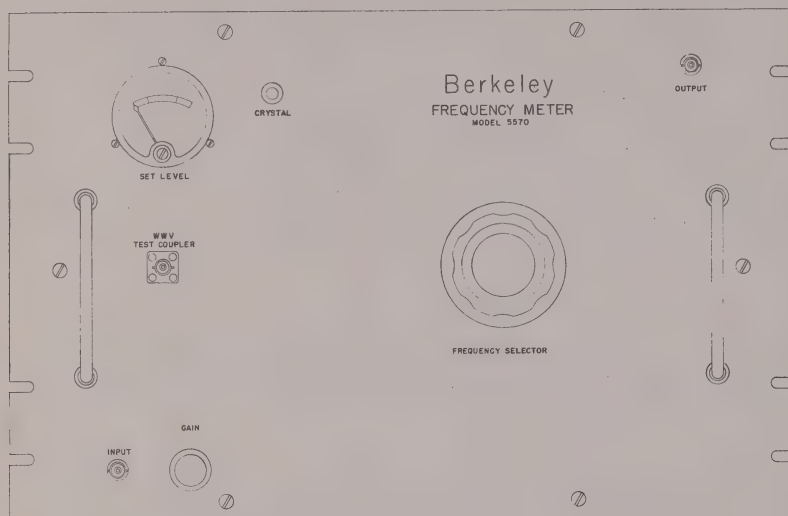
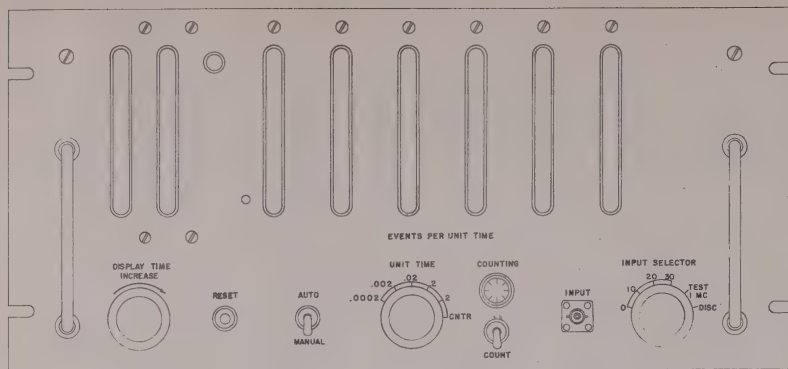
Instrument should read 1,000,000

To measure frequencies below 2 MC:

1. Connect unknown signal to INPUT SOCKET of INDICATOR UNIT
2. Turn INPUT SELECTOR to 0, 10, 20 or 30 DB for consistent readings

To measure frequencies from 2 to 42 MC:

1. Connect unknown signal to INPUT of HETERODYNE UNIT and patch across from OUTPUT of HETERODYNE UNIT to INPUT of INDICATOR UNIT. Although the sensitivity is specified as



LOWER PANEL

Figure 2 Outline View, Model 5570 Frequency Meter

Table 1
CONTROL & CONNECTOR FUNCTIONS

<u>Control or Connector</u>	<u>Detail No.</u>	<u>Component</u>	<u>Function</u>
<u>Front Panel</u>			
INPUT	J405	BNC type UG-290/U	Connector for input frequencies above 2 Mc
GAIN	R440	100 ohms 2W Potentiometer	Attenuates input signal
FREQUENCY SELECTOR	Turret Switch	Special Berkeley switch	Selects precision reference frequency
OUTPUT	J404	BNC type UG-290/U	Connector for low frequency beat
INPUT	J101	BNC type UG-290/U	Connector for input frequencies below 2 Mc and low frequency beat from Heterodyne unit
DISPLAY TIME INCREASE	R153	10 ohms 2W Potentiometer	Varies display time
RESET	S105	SPDT toggle switch	Optional manual reset
AUTO-MANUAL	S103	SPDT toggle switch	Optional manual reset
COUNT	S104	SPDT toggle switch	Optional manual reset
UNIT TIME	S102	2-Deck Rotary switch	Selects output from time base dividers
INPUT SELECTOR	S101	5-Deck Rotary switch	Selects input circuit
<u>Rear Chassis</u>			
EXTERNAL 1 MC. INPUT	J402	BNC type UG-290/U	Connector for use of external 1 Mc standard

<u>Control or Connector</u>	<u>Detail No.</u>	<u>Component</u>	<u>Function</u>
<u>Rear Chassis</u>			
1 MC OUTPUT	J401	BNC type UG-290/U	Connector for precision 1 MC output (for use with accessories)
HETERODYNE UNIT J104	J104	AN 3102 A-18-S-1S	Power supply for heterodyne unit
HETERODYNE UNIT J105	J105	AN 3102 A-20-27S	Connector for control lights
FAN	J106	CINCH Receptacle	Line voltage for fan
INPUT 1 MC J102	J102	BNC type UG-290/U	Connects precision 1 MC from Heterodyne UNIT for time base synchronization
DIGITAL RECORDER J103	J103	AN 3102 A-18-12S	Connects to Berkeley Model 1556 Digital Scanner

100 mv rms the instrument is considerably more sensitive than this over a major portion of its range. When searching for an entirely unknown frequency, keep the input level at about 100 mv to avoid over drive.

2. Set INPUT SELECTOR to 0 DB
3. Turn Frequency Selector in a clockwise direction from a value known to be below the frequency to be measured until the level meter shows a marked deflection. Set level meter in green region by adjusting gain.
4. Read final answer on Indicator unit

Calibration of internal crystal. Simultaneously, connect the WWV TEST COUPLER and an external antenna to the input of a communications receiver. Set the crystal frequency by varying the trimmer capacitor on the front panel until a zero beat is obtained on WWV frequencies of 5, 15, 20 or 25 megacycles. A special alignment tool has been supplied for this purpose.

Use of precise one megacycle reference frequency:

1. Remove internal crystal
2. Inject external signal into J402 which may be reached from the rear of the cabinet. A minimum level of 0.5 volts rms at high impedance is required.

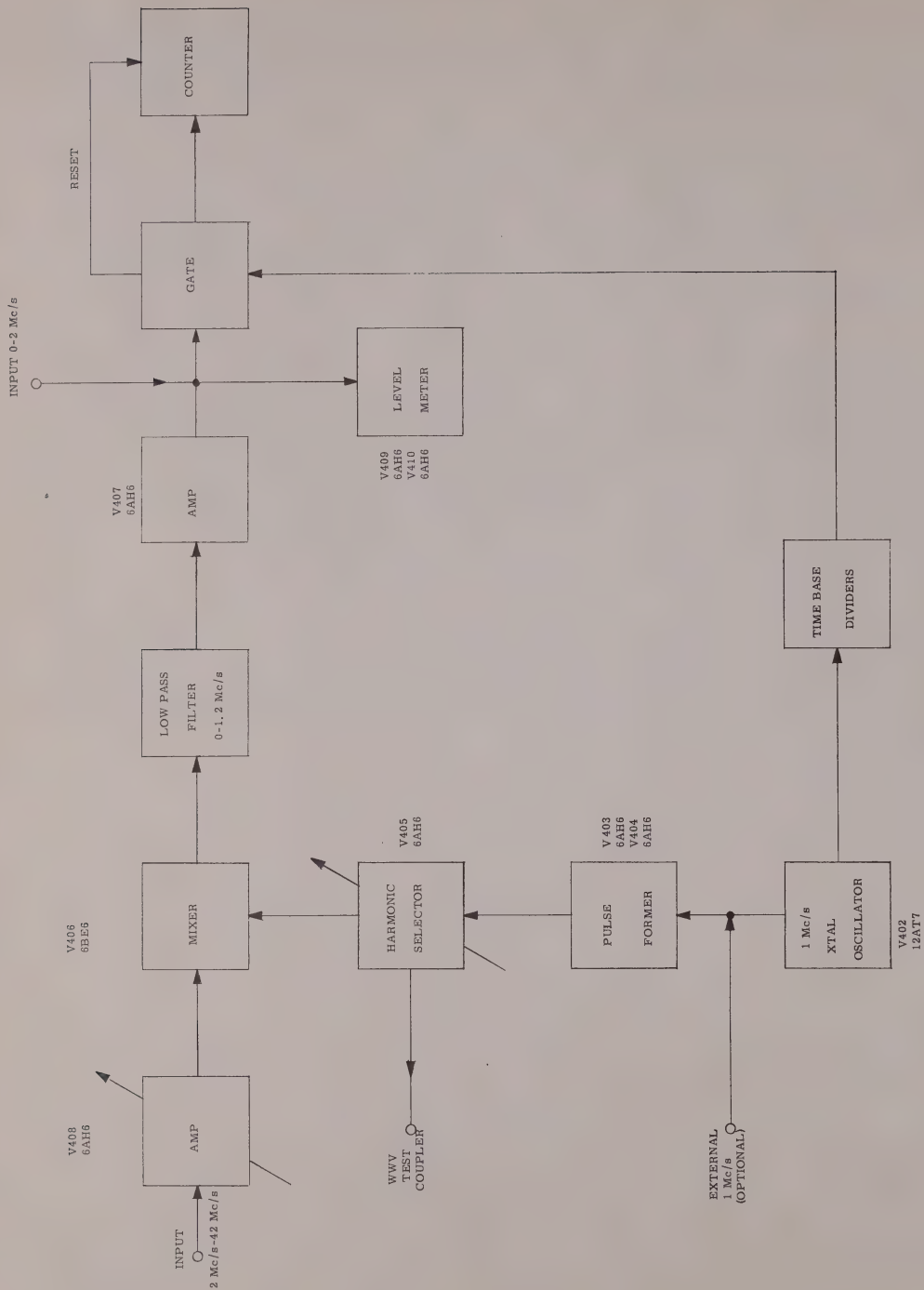


Figure 3 Functional Diagram Model 5570

Section 3 THEORY OF OPERATION

Design

Basically, the Model 5570 consists of a Heterodyne unit, Events-per-Unit-Time meter, and a Power supply. The Heterodyne unit includes an amplifier, a mixer, harmonic selector, pulse former, and a one megacycle per second crystal oscillator. The EPUT section which is similar to the Model 5558 contains an accurate time base, electronic gate, and a system of cascaded Decimal Counting Units (DCU's).

Figure 3 is a functional diagram of the complete instrument. The Gate Counter and Time Base Dividers form the Indicator unit and the remaining sections, the Heterodyne unit. A third unit supplies power for the instrument. The Indicator unit is a complete counting instrument with a maximum frequency response of 2 MC. The Heterodyne unit converts high frequencies to frequencies within the range of the Indicator unit.

The Heterodyne Unit

An unknown frequency is amplified by V408 and applied to the first control grid of mixer V406 (see Figure 4). A precise reference frequency of any integral number of megacycles between 2 and 41 may be applied to the second control grid of V406 (pin 7) as selected by the turret switch. The plate circuit of V406 consists of a three section low pass filter with a cut-off frequency of approximately 1.2 Mc. If the two frequencies injected into V406 are less than 1.2 Mc apart, a beat frequency is produced which passes through the low pass filter to reach the output amplifier V407. Further amplification of this beat frequency by V409 and V410 drives the Set Level meter (M401).

Precise reference frequencies are derived from a highly stable crystal oscillator (V402). In this circuit the amplitude of oscillation is automatically controlled by the positive feedback thermister I401 and the frequency governed by the frequency at which Y401 and C403 are in series resonance. The 1 Mc output from this oscillator is amplified by V403 and the very large amplitude applied to the grid of L404 causes L402 to ring.

The first positive going overshoot causes a large current pulse to flow in the plate circuit of V405. L403 is a low loss coil tuned by capacitors selected by the turret switch to integral frequencies between 2 and 41 Mc. A very high Q is maintained over the entire range so that the tuned circuit extracts the proper frequency component from the applied pulse. A single turn coupling loop (L405) couples a small amount of energy to V406 at the desired reference frequency (see Figure 9).

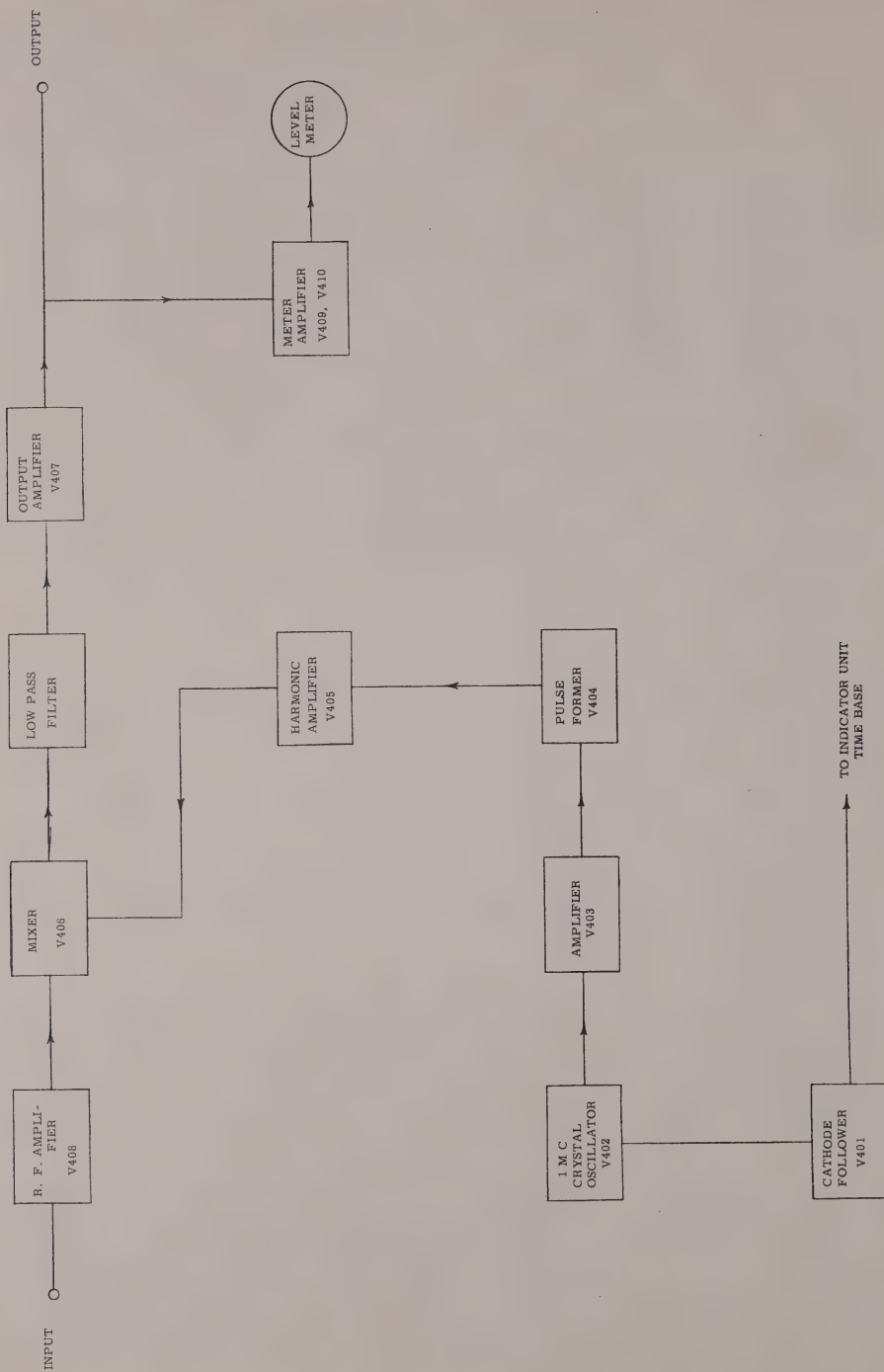


Figure 4 Functional Diagram Heterodyne Unit

Indicator Unit

The Indicator unit consists of an input circuit, an electronic gate opened and closed by a time base synchronized with a 1 Megacycle precision sine wave from the Heterodyne unit, and a series of six electronic decade counting units (see Figure 5). Input signals are amplified, shaped and conducted to an electronic gate. The gate is opened by a signal from the time base, remains open for an accurately controlled interval, and closes on a second signal from the time base. After the gate closes, the total number of events counted is displayed on the illuminated DCU panels. A switch on the front panel allows the operator to disconnect the time base from the gate and to use the instrument as an ordinary counter. The basic accuracy of this unit is essentially $\pm$ one event for any input frequency, the irreducible error of all electronic counters. (see Figure 8).

Input attenuator. The input signal is coupled to the amplifier through an attenuator which consists of three frequency compensated voltage dividers, 10, 20 and 30 decibels attenuation, respectively. The 0 db attenuation position makes a direct capacitive coupling between the input and the amplifier. The three-tube feedback loop type input amplifier has a fixed feedback gain of about 100. Considerable gain stability is achieved with the feedback circuit. From 10 to 2,000,000 cps, the frequency response only varies 3 db.

Schmitt discriminator. The output signal of the input amplifier operates a Schmitt discriminator circuit, a circuit with two stable states. It remains in one state as long as the input signal is zero or remains below a certain amplitude, and switches to the other state when the input signal amplitude exceeds this value.

Potentiometer R121 controls the triggering level of the input grid which in turn determines the input sensitivity of the unit. R121 is normally set for maximum sensitivity. About 30 milivolts rms at the input is a typical requirement. The output from the Schmitt drives a binary circuit via V105 and CR102 and CR103. For every two cycles of the input signal, an output pulse is obtained from this stage.

L101 in the right plate circuit of V111 is paralleled with the stray capacity across it to form a ringing circuit with a resonant frequency of about 1.5 megacycles. CR104 and R188 prevent oscillation after the first half-cycle to produce a positive pulse with a period of 0.35 microseconds and an amplitude of 10 volts. This pulse, applied to the signal gate tube V112 through C149, drives the first DCU (AY101).

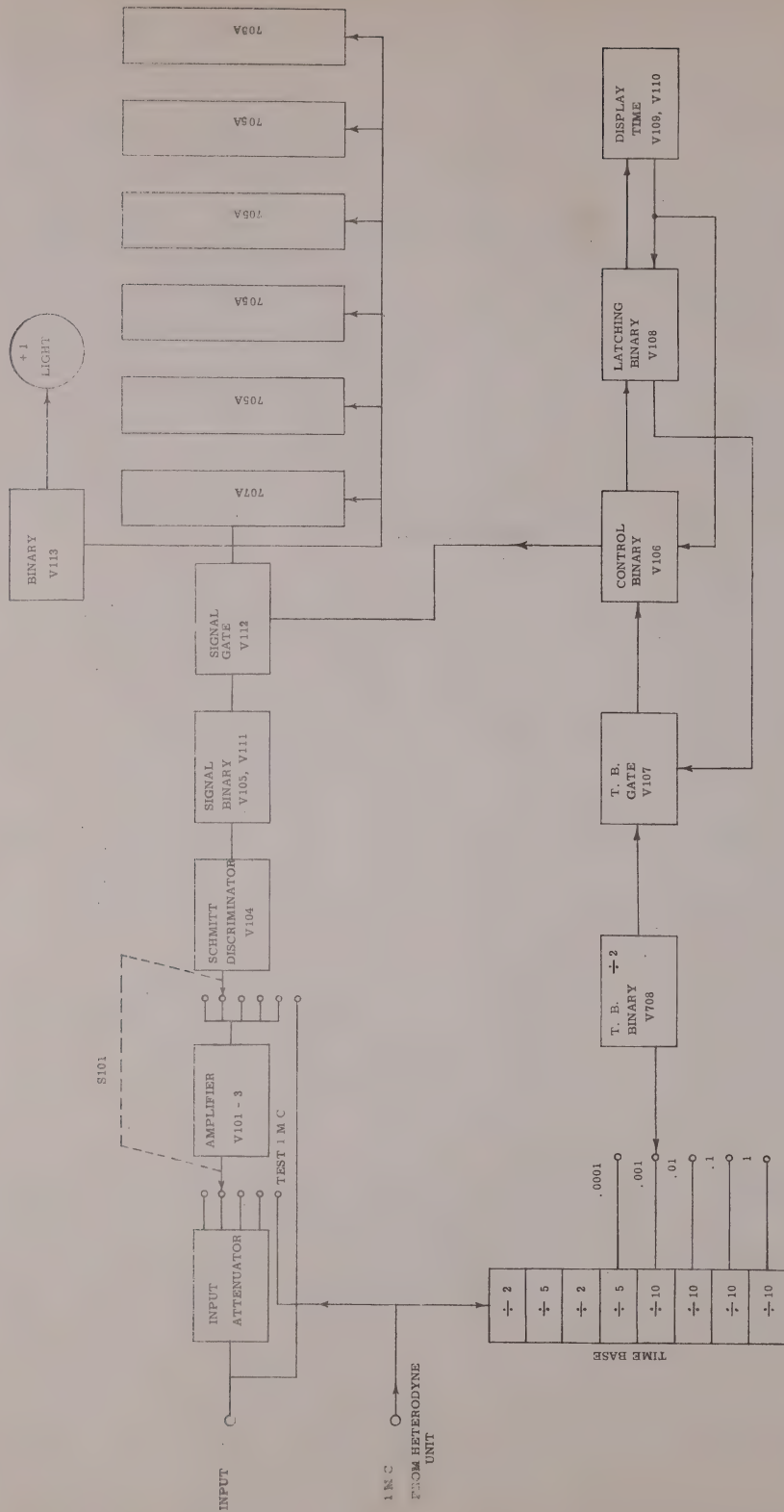


Figure 5 Functional Diagram Indicator Unit

Signal gate. V112 the signal gate, has two control grids, one obtains its signal from the input binary circuit (V111); the other, from the control binary, V106. The plate of the signal gate tube is connected directly to the cathodes of the triggering diodes in the Model 707A (See Appendix B). The second control grid of V112 (pin 7), connected to the control binary, is held at ground potential by the control binary during the counting period. During the remainder of the counting cycle, this grid is held below its cutoff voltage. The first grid of V112 (pin 1), connected to the input binary circuit (V111) is normally biased below cutoff. Positive pulses from the input binary circuit raise this grid above the cutoff point and during the counting period, initiate a current flow through V112, which drives AY101.

Time base gate and control and latching binaries. These units are interdependent, and are therefore discussed jointly. The cathodes of V107 are connected to ground through R140. Since the grids of V107 are d-c connected through R138 and R139 to their respective plates and a-c coupled to the cathodes, either half of V107 acts as a diode when its plate is at or near ground. Each plate of V106, the control binary (which is connected directly to the plate of V107), is near ground potential in the non-conducting state. The potential of the conducting plate (thus the corresponding plate and grid of V107) is considerably below ground. Rectangular waveforms from the time base are differentiated by C127 and R140, producing alternate positive and negative pulses at the cathodes of V107. Positive pulses raise the cathodes above ground so that no conduction occurs through V107; negative pulses cause one side or the other to conduct. The half of V107 conducting is connected to the plate of the non-conducting side of the control binary, V106. In this way, a negative signal from the time base causes the control binary to change to its opposite state, either starting or terminating the counting period. At the beginning of the counting period the control binary is changed from one state to the other. If the right side conducts, the left cuts off. V108, the latching binary, is designed so that when its right side conducts, the left side cuts off. The positive pulse introduced by the control binary through C120 at the start of the counting period does not alter this condition. At the end of the counting period, however, the left plate of V106 goes negative, applying a negative pulse through C120 to the right grid of V108 via the cross-over network which causes the latching binary to change to its other state. Two actions occur as a result of this change.

First, the divider R138 and R161 lowers the grid of V107 to a potential below ground which cuts off this half of V107 (the plate and grid of the other half are already below the cathode potential.) When the next pulse from the time base arrives at the cathodes of V107, the grids are carried by C120 and C133. As long as the latching binary holds the V107 grid below cathode potential, the control binary cannot be triggered from the time base and V112, the signal gate tube, is cut off, which prevents pulses from reaching the 707A DCU (AY101).

Second, the half of V110 whose grid is connected to the left plate of V108 is cut off, allowing C124 to charge up through R151 and R153. The voltage across C124 increases until the firing potential of the thyatron V109 is reached, causing it to fire, producing a positive voltage pulse across the cathode resistor, R154. This pulse resets the DCU's. It also resets the control and latching binaries through R154 connected to the left and right grids, respectively. Normally, the control binary has been reset at the end of the counting period, but the reset pulse assures proper position for the next counting cycle. Additionally, the bias from the grids of V107 and V110 is removed, permitting the former to function as a diode and the latter preventing C124 from charging up to the firing potential of thyatron V109. From this state, the circuit will respond to the next counting cycle which begins when the next pulse from the time base triggers the control binary.

The DISPLAY TIME (R153) setting determines the charging time of C124. R158, which controls the firing potential of V109, is factory adjusted for a maximum display time of about seven seconds, S108 AUTO-MAN, disconnects the common plates of V109 and V110 from their voltage supply which prevents the automatic reset from operating. The RESET pushbutton connects a positive potential to the plate of V109 and causes the DCU's and control and latching binaries to be reset similarly to the manner of the automatic reset circuit. With the UNIT TIME in COUNTER, S104, the COUNT switch, opens the cathode circuit of either half of the control binary, V106, forcing it to either of its two states. Thus, with the circuit in manual operation, the instrument can be operated as a counter.

Time Base

The time base consists of a 500 Kc blocking oscillator synchronized by a precision 1 Mc sine wave fed from the Heterodyne unit, followed by a chain of dividers (V701 to V707). The output from the last divider provides pulses at intervals of precisely 1 second. The time base output is connected to the gating circuit via the time base binary V708, a maximum sampling period of 2 seconds is thereby achieved (see Figure 7).

Operation As A Pulse Counter

For repetition rates not exceeding 2 Mc the Indicator Unit may be used as a pulse counter. So used, set up the Schmitt circuit as follows:

1. Set R121 in the extreme clockwise position so that the right side of V104 conducts.
2. Apply a positive d-c voltage of 7 volts to the input connector with the attenuator switch on DISCR.

3. Rotate R121 in a counterclockwise direction until V104 triggers and cuts the right side off.
4. Remove the d-c voltage. V104 should trigger back, the right side conducting. Failure to trigger is indicative of a faulty tube or component.

To adjust the input circuit for response to negative pulses alone, the procedure detailed above is followed except that in (1), R121 is placed in the extreme counterclockwise position; (2) a negative d-c voltage is applied; (3) R121 is rotated clockwise and the left side cut-off, and (4) the left side conducts.

Power Supply

The power supply provides 6.3 volts 60 c/s for the heating of filaments and four different direct voltages as listed.

- +290 volts unregulated
- +120 volts regulated
- 150 volts regulated
- 300 volts unregulated

Design is conventional, regulation is achieved electronically using the potential drop across a gas filled tube (OB2) for reference.

Section 4 MAINTENANCE

Before leaving the factory, this instrument was carefully aligned. Readjustment should not be necessary for a long time. Normally, the replacement of a tube or component will have no effect on the operation except in the Time Base. Properly aligned sets have been operated for many months without readjustment.

Where faulty operation is suspected, do not attempt to service the instrument without reference to the Service Chart (Table 2). Proceed according to the directions therein before taking any remedial action.

Routine Adjustments

Trigger Adjust. R187 controls the drive voltage on the first DCU (AY101). To adjust this voltage set the INPUT SELECTOR on 1 Mc and vary R187 until the extreme positions for correct counting have been determined. Repeat this adjustment using a 10 Kc external signal. The inner positions for each frequency delineate the region of proper operation over the whole frequency range. Set R187 midway between these two points.

Schmitt Discriminator. R121, the DISC ADJ, controls the Schmitt circuit. To set this circuit for maximum sensitivity, turn UNIT TIME to CNTR, inject an external signal of any frequency between 1 Kc/sec and 1 Mc/sec and alternately adjust R121 and lower the input level until the maximum sensitivity is reached (about 30 millivolts rms).

Time Base. To properly adjust the time base, adhere strictly to the following procedure:

1. Check level of 1 Mc input at P102.
2. Connect wide-band scope to test point Eo and check waveform A. Pay particular attention to the regularity of the $2\mu\text{s}$ pulses (waveform B is not acceptable).
3. If the waveform at Eo is incorrect, disconnect the 1 Mc input from J102 and adjust DIV 1 and DIV 2 for the correct waveform.

4. Replace 1 Mc input and readjust DIV 1 only to regain correct picture.
5. Move scope to E1 and adjust DIV 3 for division by 5 (waveform C).
6. Turn UNIT TIME to .0002 and cross check previous adjustments by observing count of 100 ± 1 .
7. Turn UNIT TIME to .002 and adjust DIV 4 for a count of 1000 ± 1 .
8. Turn UNIT TIME to .02, adjust DIV 5 for a count of $10,000 \pm 1$.
9. Turn UNIT TIME to .2, adjust DIV 6 for a count of $100,000 \pm 1$.
10. Turn UNIT TIME to 2, adjust DIV 7 for a count of $1,000,000 \pm 1$.
11. Return UNIT TIME to .0002 and readjust DIV 1, DIV 2, DIV 3 for center of respective ranges which produce counts of 100 ± 1 .
12. Turn UNIT TIME to .002 and set DIV 4 to center of range (count 1000 ± 1).
13. Turn UNIT TIME to .02, set DIV 5 to center (count $10,000 \pm 1$).
14. Turn UNIT TIME to .2, set DIV 6 to center ($100,000 \pm 1$).
15. Turn UNIT TIME to 2, set DIV 7 to center ($1,000,000 \pm 1$).
13. Repeat 11 to 15 until all dividers have range of at least $\pm 20^\circ$.
17. Vary line voltage between 105 and 130 volts. The count should hold $1,000,000 \pm 1$ (UNIT TIME at 2).

Table 2
SERVICE CHART

Follow procedure in strict sequence:

	TEST	OBSERVED RESULT	ROUTE
T1	Input selector to "TEST X 1 Mc", UNIT TIME to 2	Count 1, 000, 000 ± 1	Proceed to T12
		Count not 1, 000, 000 ± 1	Proceed to T2
T2	UNIT TIME to .2	Count 1, 000, 000 ± 1	Return to T1. Adjust DIV 7 or replace DCU AY106
		Count not 100, 000 ± 1	Proceed to T3
T3	UNIT TIME to .02	Count 10, 000 ± 1	Return to T2. Adjust DIV or replace DCU AY104
		Count not 10, 000 ± 1	Proceed to T4
T4	UNIT TIME to .002	Count 1, 000 ± 1	Return to T3. Adjust DIV 5 or replace DCU AY104
		Count not 1, 000 ± 1	Proceed to T5
T5	UNIT TIME to .0002	Count 100 ± 1	Return to T4. Adjust DIV 4 or replace DCU AY103
		Count not 100 ± 1	Proceed to T6
T6	Check waveform C (Figure 6) at test point E1	Correct	Return to T5. Adjust TRIGGER ADJ. RESET RANGE ADJ. or replace DCU AY102 or AY101
		Waveform correct but division ration not 5 or unsteady	Proceed to T7
		Wave shape incorrect	Proceed to T11

	TEST	OBSERVED RESULT	ROUTE
T7	Check waveform A (Figure 6)	Correct	Return to T6. Adjust DIV 3
		Incorrect or unsteady	Proceed to T8
T8	Check level of 1 Mc INPUT (P102)	More than 3 volts peak to peak or 1 volt rms.	Proceed to T9
		Less than 3 volts peak to peak or 1 volt rms.	Proceed to T10
T9	Re-align time Base		Return to T1
T10	Replace tube V401		Return to T1
T11	Check voltages and waveforms of V702		Return to T1
T12	UNIT TIME to 2 Swing line voltage slowly between 105 and 130 volts	Count always 1,000,000 ± 1	Proceed to T13
		Count not always 1,000,000 ± 1	Return to T9
T13	INPUT SELECTOR to 0 db. Inject sine wave at 10 Kc/s.	Correct count	Proceed to T14
		Incorrect count	Reset TRIGGER ADJ.
T14	Reduce 10 Kc/s level to minimum for correct count	Level more than 50 millivolts rms	Proceed to T15
		Level less than 50 millivolts rms	Proceed to T16
T15	Reset "DISC ADJ."		Proceed to T16
T16	Check waveform and level of signal being injected to input of INDICATOR UNIT under condition where failure is obtained.		
T17	See Troubleshooting		

Troubleshooting

Schematics, waveforms and several maintenance charts have been included in this section as servicing aids. Proper troubleshooting requires a good VTVM and a high quality oscilloscope. In the event of failure, follow the procedure described in Table 2. Table 3 lists several of the more common troubles. This list is by no means exhaustive, but should serve as a guide. As in any electronic device, tubes are the most frequent cause of failure.

Table 3
TROUBLESHOOTING CHART

(A) Indicator unit fed directly from external signal (Frequencies below 2 Mc).

Symptom

Correct count on Test, incorrect on external signal.	Input level too high or too low - check by adjusting INPUT SELECTOR.
Correct count at high frequency but incorrect at low frequency.	707A. Try resetting TRIGGER ADJ.
Reads 1249 or 125 in TEST position.	707A. Try resetting TRIGGER ADJ.
Reads 2000 or 1999 in TEST position.	707A. Try resetting TRIGGER ADJ. Check binary V111.

(B) All sections of instrument in use. (Frequencies above 2 Mc).

Meter deflection independent of position of Frequency Selector.	Input cable picking up signal below 2 Mc. or Signal has low frequency modulation and GAIN is too high.
Instrument apparently normal in behavior but count is low or erratic.	Signal has amplitude modulation in excess of 30% Check beat frequency waveform at OUTPUT socket of Heterodyne unit. or Indicator Unit insensitive Check "DISC ADJ."

Meter continuously deflected without input signal (instrument near source of very strong signal).

Instrument apparently normal but count is high and erratic when measuring low frequency beats.

First two columns of lights in indicator section fail to light correctly.

Failure of R. F. filter in power supply unit

or

Front panel of Heterodyne unit not properly fastened

Meter circuit insensitive resulting in overdrive of counter. Reset R446 as follows: inject 200 Kc signal directly into Heterodyne unit and adjust level until VTVM or oscilloscope connected to OUTPUT socket shows 90mV rms. Adjust R446 until meter reads at lower red/green boundary.

Rear set of contacts behind turret switch in Heterodyne unit require adjustment. Right hand side of chassis may be removed to allow inspection.

All voltages shown on the circuit diagrams were measured relative to chassis with a VTVM with the instrument controls set as follows:

DISPLAY TIME	anti-clockwise
AUTO/MANUAL	AUTO
UNIT TIME	.0002
COUNT	on
INPUT SELECTOR	TEST 1 Mc.

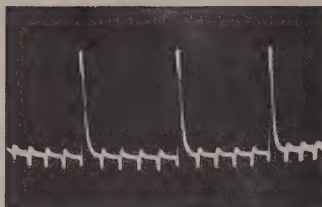
Table 4
VOLTAGES

<u>Tube</u>	<u>Pin No.</u>	<u>Voltage</u>	<u>Remarks</u>
V708	1, 6	230	V708 removed
V708	2, 7	59	V708 removed
V111	1, 9	97	V111 removed
V111	2, 7	52	V111 removed
V113	1, 6	210	V113 removed
V113	2, 7	68	V113 removed
V106	1	8	V106, V108 removed
V106	2, 7	-105	V106, V108 removed
V106	9	6.5	V106, V108 removed
V108	1	9	V106, V108 removed

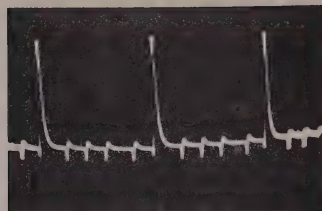
The potentials listed above were measured under the same conditions except as indicated.

NOTE

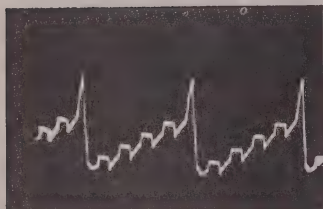
The following photographs were taken from a Tektronix 514D oscilloscope with a 4x5 Grover View camera at f4.5 at $\frac{1}{2}$ second.



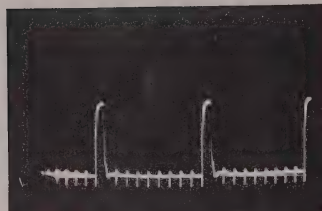
A. Test point E_0 (correct waveform), 26 volts peak-to-peak, 10 μ secs. between positive peaks.



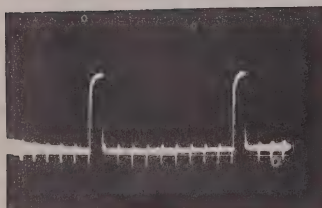
B. Test point E_0 (incorrect waveform).



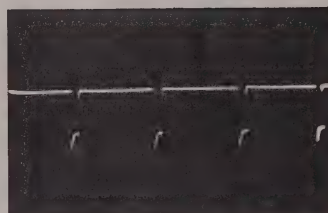
C. Test point E_1 , 17 volts peak-to-peak, 100 μ secs. between positive peaks.



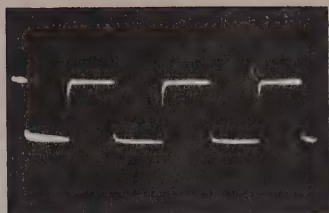
D. Test point E_2 , 80 volts peak-to-peak, 1000 μ secs. between positive peaks.



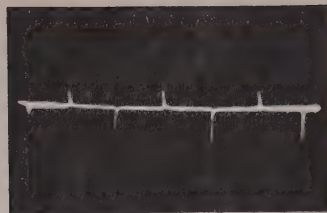
E. Test point E_3 , 80 volts peak-to-peak, 10 milliseconds between positive peaks.



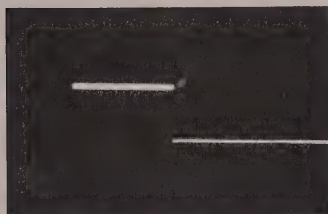
F. Input to Time Base output binary (pin 6 V706). Unit Time switch at .002, 83 volts peak-to-peak.



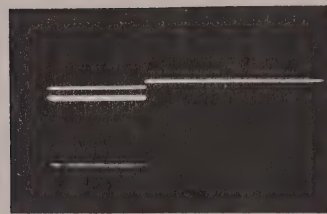
G. Time Base output to gate circuits (junction R791 and C127). Unit Time switch at .002, 120 volts peak-to-peak.



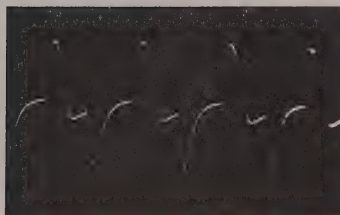
H. Differentiated input to gate circuits (pin 3, 8 of V107). Unit Time switch at .002, 98 volts peak-to-peak.



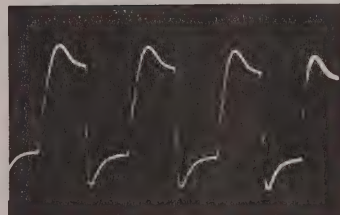
J. Gate control waveform (pin 7, V112). Unit Time switch at .002, 28 volts peak-to-peak.



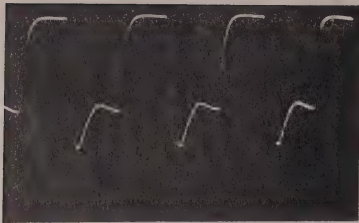
K. Gated output (pin 5, V112). Unit Time switch at .002. Input Selector at TEST 1 MC., 50 volts peak-to-peak.



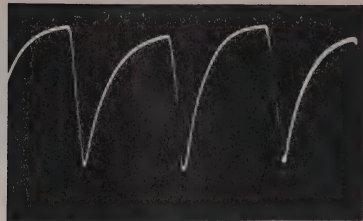
L. Signal input to gate (pin 1, V112). Input Selector in TEST 1 MC. position, 24 volts peak-to-peak.



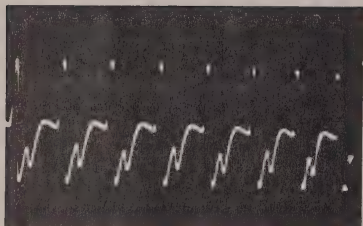
M. Output from signal binary (pin 9) V111. Input Selector in TEST 1 MC. position, 60 volts peak-to-peak.



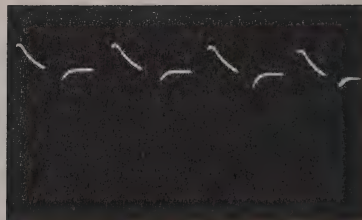
N. Output from signal binary (pin 1, V111).
Input Selector in TEST 1 MC. position,
60 volts peak-to-peak.



O. Input to decimal counter units (pin 5, V112), Unit Time switch in CNTR position, Input Selector in TEST 1 MC. position, 50 volts peak-to-peak.



P. Output from Schmitt discriminator
(pin 1, V105), Input Selector in TEST
1 MC. position, 30 volts peak-to-peak.



Q. Input to signal binary (pin 5, V105),
Input Selector in TEST 1 MC. position,
30 volts peak-to-peak.

Section 5 PARTS LIST

Non-Standard Components

<u>Detail No.</u>	<u>Stock No.</u>	<u>Item</u>	<u>Description</u>	<u>Manufacturer & No.</u>
<u>Heterodyne unit</u>				
L406				
L408	3-3198	Inductor	1 MH W/Shield	Carad
L402	3-3079	Inductor	12 Microhenries	Carad
L403-L405		Inductor	Special	BSC
P401	11-3259	Plug		Cannon AN 3108B-20-27P
P402	11-3258	Plug		Cannon AN 3108B-18-1P
P403	11-3239	Plug	2 M, W/1119 PH Contacts	Elco "Varicon"
	11-2081	Plug		IPC UG 260/U
Y401	13-3073	Crystal	Series resonant at 1 Mc with 5 μ f Series capacitance	Bliley BH8 Oven Type TC92
M401	15-3099	Meter	0-1 MA Special Scale	Scale Weston Mod. 506 W/D149625
J401-J405	17-0849	Receptacle		IPC 2700
J406	17-3238	Receptacle	2(F), W/2 #1101 Brackets, Black bakelite W/Hardware	Elco, "Varicon"
	17-2798	Receptacle	AN 3064-10	
I401	21-3202	Lamp	120 V, 3 Watts	GE 3-S-6

<u>Detail No.</u>	<u>Stock No.</u>	<u>Item</u>	<u>Description</u>	<u>Manufacturer & No.</u>
		Indicator Unit		
L101	3-3183	Choke	250 Micro-H.8 Ohm, 125 MA	Carad
T101	6-2614	Transformer	Filament	Triad #9400
T701	6-3101	Transformer		Triad X-20284
T702	6-3271	Transformer	Miniature Pulse (Blue)	PCA 101-2
CR101-CR104	8-0668	Diode	Crystal Diode	1N34A
P101	11-2703	Plug Connector	14 Conductor	AN 3106V-28-2P
S101	12-2633	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S102	12-3201	Switch	Special 3 Pole, 6 Pos. Rotary	Oak Mfg. Co.
S103	12-1641	Switch	SPDT Toggle	CH 8282K13
S104		Switch	Same as S103	
S105	12-0879	Switch	Micro-switch	BZ-2RQ1
J101	17-0849	Connector	IPC Input Connector	LV-2700 290/U
J102		Connector	Same as J101	
J103	17-2713	Receptacle	6 Pin Socket	AN 3102A-18-12S
J104	17-1665	Receptacle	10 Pin Socket	Cannon AN3102A- 18-S-1S
J105	17-2603	Receptacle		Cannon AN3102A- 20-27S
	17-2798	Connector	Box Type	Cannon AN3064-10

<u>Detail No.</u>	<u>Stock No.</u>	<u>Item</u>	<u>Description</u>	<u>Manufacturer & No.</u>
J106	17-1748A	Receptacle		Cinch 12844
	20-0735A	Feed Thru		Unesco 1433
I101	21-1679	Neon Lamp	1/25 W, 105-125V	GE NE 51
I102-I116	21-0426	" "		NE 2
Power Supply				
L301	3-2615	Choke	Hermetically sealed Filter 10H, 300MA, 85 Ohm	Triad Type #HS-319 14261
L302	3-2616	"	Filter 15H, 120MA, 185 Ohm	Triad Type #HS-307 14262
L303	3-3170	"	5.5 Micro-H	Carad Corp.
L304			Same as L303	
T301	6-2612	Power Trans- former		Triad #7188
T302	6-2083	Filament Trans.		Triad 9518
F301	7-2601	Fuse	8 Amp. 125V	Littelfuse 312008
F302		"	Same as F301	
F303	7-1099	"	$\frac{1}{2}$ Amp. 250V	Littelfuse #312500
F304		"	Same as F303	
CR310-CR302	8-1699A	Selenium Rectif.		Selectron 6 M1
S301	12-1642	Switch	DPST Toggle	CH 8370K8
J301	17-3185	Connector		Hubbel 7486
J302	17-2642	"	14 Hole, Box mounting receptacle	Cannon AN 3102A-28-2S

<u>Detail No.</u>	<u>Stock No.</u>	<u>Item</u>	<u>Description</u>	<u>Manufacturer & No.</u>
I301	21-1677	Lamp, Pilot	15A, 6-8V	GE #47
I302		Lamp, Pilot	15A, 6-8V	

Tube Complement

<u>Type</u>	<u>No. Required per Unit</u>
-------------	------------------------------

Heterodyne unit

8*	6AH6	8 (V401, 403, 404, 405, 407, 408, 409, 410)
1*	12AT7	1 (V402)
1*	6BE6	1 (V406)

Indicator unit

3*	6AU6	3 (V101, 102, 105)
1*	5964	1 (V103)
3*	5687	3 (V104, 106, 111)
10*	5963	10 (V107, 108, 110, 113, 702, 704, 705, 706, 707, 708)
1*	2D21	1 (V109)
1*	6AS6	1 (V112)
1*	12AT7	1 (V701)
1*	12BH7	1 (V703)

Power supply

2*	5U4G	2 (V301, 302)
2*	6AS7 or 6080	2 (V303, 304)
2*	6AU6	2 (V305, 306)
2*	OB2	2 (V307, 308)

Asterisk indicates recommended spare part. Number preceding indicates quantity.

<u>Detail No.</u>	<u>Stock No.</u>	<u>Item</u>	<u>Description</u>	<u>Manufacturer & No.</u>
I301	21-1677	Lamp, Pilot	15A, 6-8V	GE #47
I302		Lamp, Pilot	15A, 6-8V	

Tube Complement

<u>Type</u>	<u>No. Required per Unit</u>
-------------	------------------------------

Heterodyne unit

8*	6AH6	8 (V401, 403, 404, 405, 407, 408, 409, 410)
1*	12AT7	1 (V402)
1*	6BE6	1 (V406)

Indicator unit

3*	6AU6	3 (V101, 102, 105)
1*	5964	1 (V103)
3*	5687	3 (V104, 106, 111)
10*	5963	10 (V107, 108, 110, 113, 702, 704, 705, 706, 707, 708)
1*	2D21	1 (V109)
1*	6AS6	1 (V112)
1*	12AT7	1 (V701)
1*	12BH7	1 (V703)

Power supply

2*	5U4G	2 (V301, 302)
2*	6AS7 or 6080	2 (V303, 304)
2*	6AU6	2 (V305, 306)
2*	OB2	2 (V307, 308)

Asterisk indicates recommended spare part. Number preceding indicates quantity.

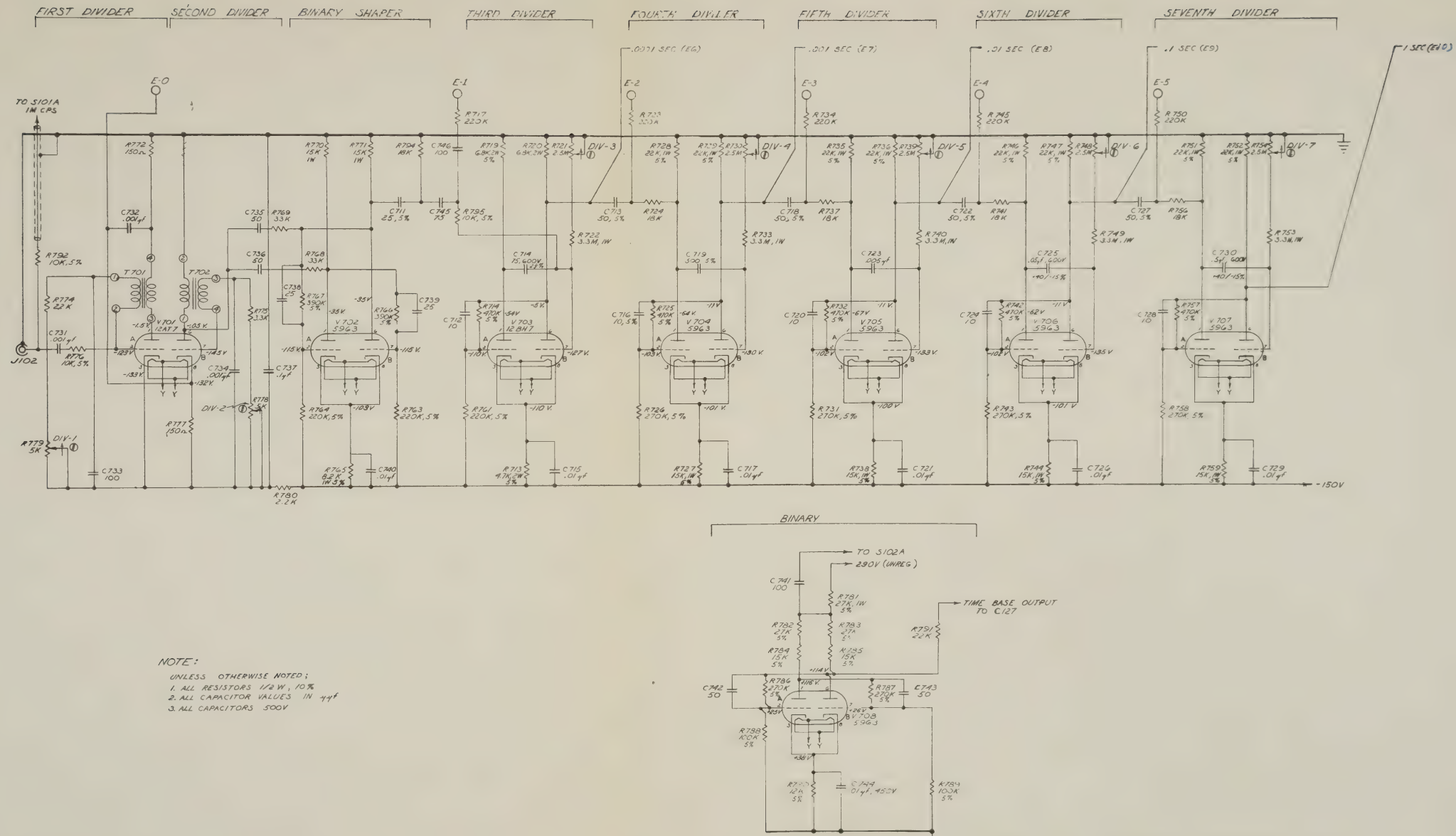


Figure 7 Schematic Diagram, Model 5570 Time Base



33

011111 7041704

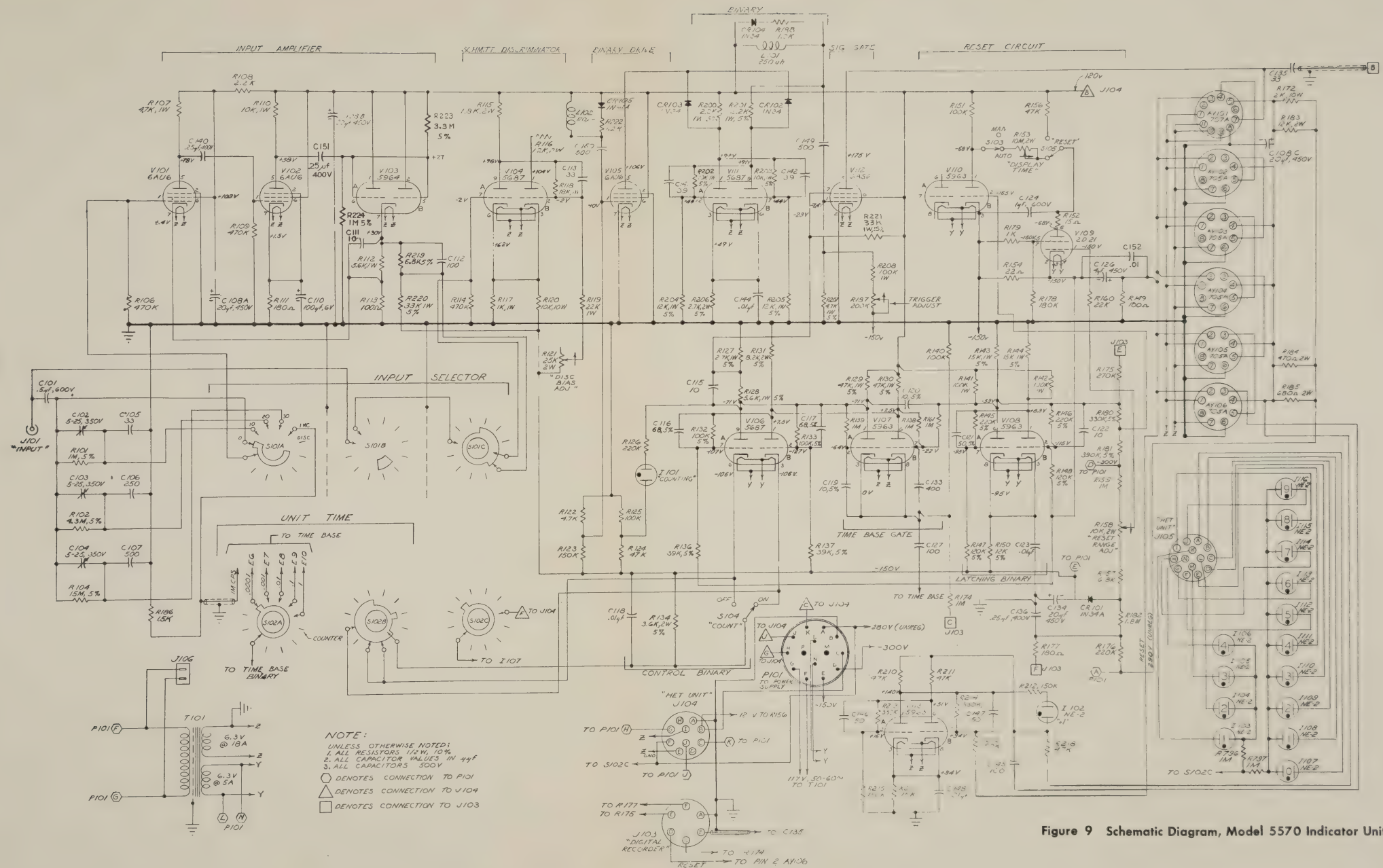
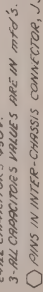


Figure 9 Schematic Diagram, Model 5570 Indicator Unit



37

Instruction
Manual

Lot 27 & up
Appendix A

Model 705A
Decimal Counting Unit

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
1 December 1953

CONTENTS

Section 1	Introduction Specifications	1
Section 2	Operation Installation Operation	2
Section 3	Theory of Operation Basic Design Circuit Analysis	3
Section 4	Maintenance Troubleshooting Diagrams and Tables	4

ILLUSTRATIONS

Figure 1	Frontispiece
Figure 2	Basic Circuit, Model 705A 3
Figure 3	Functional Diagram, Model 705A 4
Figure 4	Typical Waveshapes, Model 705A 10
Figure 5	Parts Location Diagram, Model 705A 12
Figure 6	Schematic Diagram, Model 705A 13

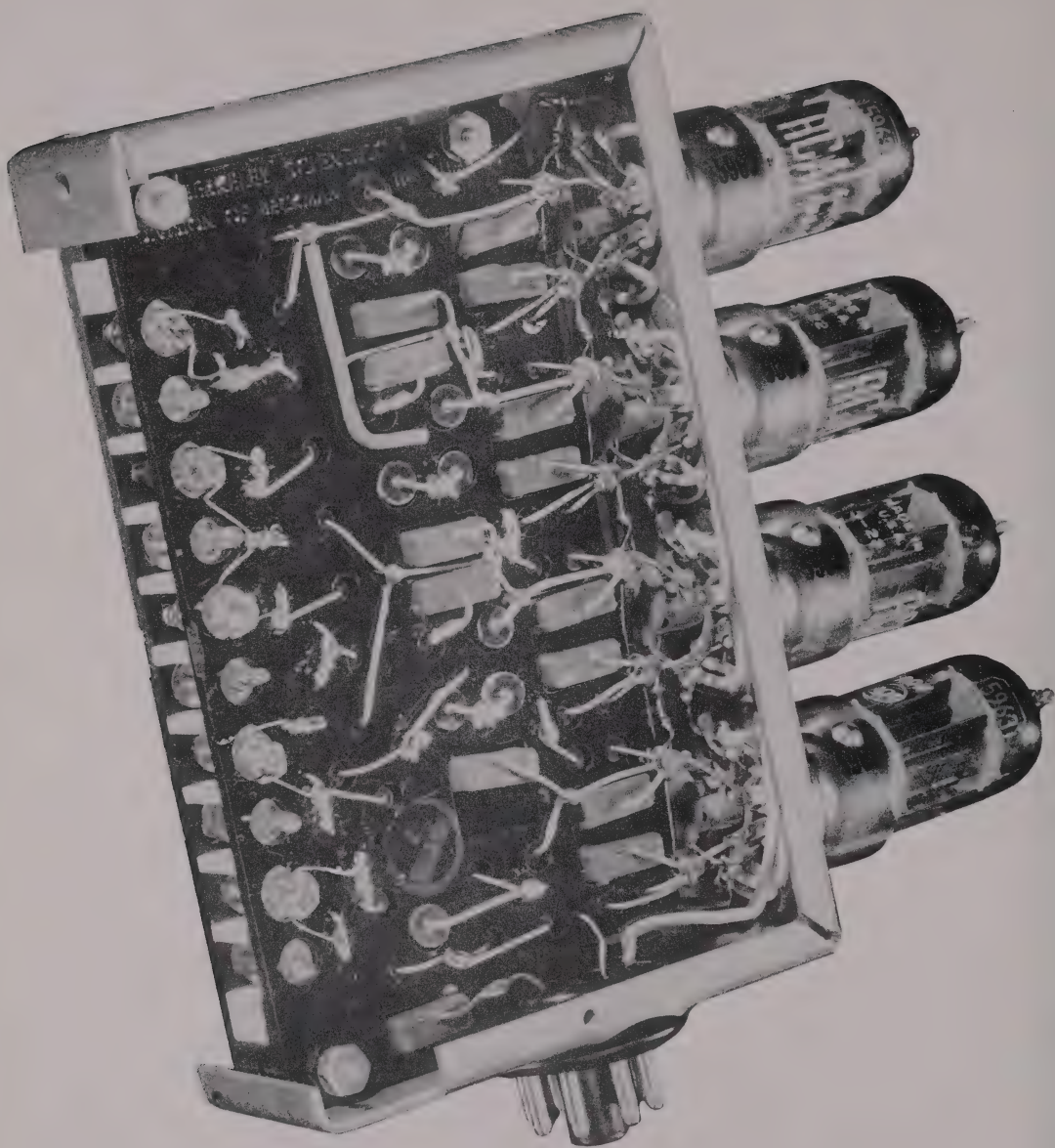


Figure 1 Model 705A Decimal Counting Unit

Section 1

INTRODUCTION

The Model 705A Decimal Counting Unit (DCU) is a direct reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of units can be connected in cascade (the output of one unit driving the next) to form a counter whose total capacity depends only on the number of DCU's. Thus, five units will count to 99,999 and reset to 00,000 on the 100,000th pulse.

Specifications

Count Indication	Direct Reading Decimal presentation
Power Requirements	Heater: 6,3 v. at 1.2 amps Plates: 300 v. at 15 ma.
Input Requirements, recommended	Negative pulse 100 volts peak amplitude
Rise Time	Less than 1 μ second
Duration	At least 2 μ seconds
Output Characteristics	Designed to drive a Model 700A, 705A, or 707A
Resolution of Paired Pulses	5 μ seconds
Reset to Zero	Instantaneous through opening of grid return
Maximum Counting Rate	100,000 cps
Construction	Plug-in unit octal socket
Dimensions	1-3/8" x 5 $\frac{1}{2}$ " x 5 $\frac{1}{2}$ "
Weight	1 lb.
Tubes	4 each 5963

Section 2 OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Operation

Power requirements:

Plates: 250 to 350 volts (nominal 300 volts at 15 ma.)

Filaments: 6.3 volts at 1.2 amperes.

Input requirements:

If the Model 705A is powered by an unregulated supply, the drive amplitude should vary with the supply voltage. A negative transient is required to drive the unit, either a square wave or a rectangular pulse at least 2 microseconds wide. The pulse amplitude depends on the rise time. For a rise time of 0.5 microseconds (measured between ten and ninety percent values), the pulse amplitude should be between 75 and 135 volts; for a 2 microsecond rise time, an amplitude of 120 to 165 volts should be used. Rise times of 1 microsecond or less, pulse amplitudes of 100 volts, and a 300 volt supply offer optimum performance. The input load presented by either unit during triggering is equivalent to 100 μf in series with 15,000 ohms.

Output requirements:

The output is a rectangular waveform presented at the output terminal as a **change** in d-c voltage (see Figure 4). Between "0" and "6", the output is 55 volts; "6" and "7", 125 volts; and "8" and "9", 135 volts. The step between "7" and "8" is caused by an interpolation network.

The load imposed on either unit must not be more than 300 K to ground or 6K in series 100 μf .

Section 3 THEORY OF OPERATION

Basic Design

The basic circuit of the Model 705A is a modification of the Eccles-Jordan trigger circuit with two stable states, referred to as a binary. It is a two-stage amplifier with the output of the second stage connected to the input of the first, as shown in Figure 2.

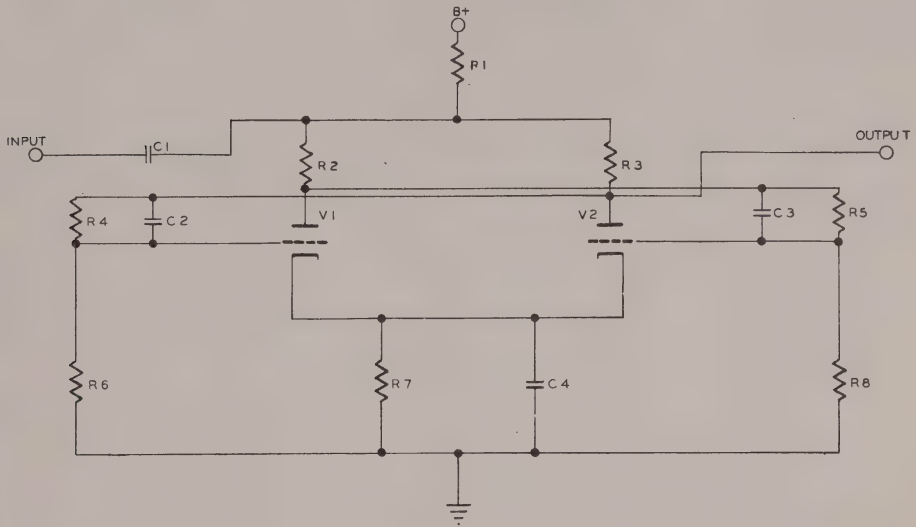


Figure 2 Basic Circuit, Model 705A

With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i. e., either V2 conducting and V1 cut off, or vice-versa. The circuit is triggered from one state to the other by making the loop gain greater than one. The binary is coupled to a single trigger source through C1 and R1 in such a way that the effect of the trigger is different on the two stages, depending on which stage is conducting. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1.

This drop in voltage is transmitted through the cross-over network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. When the input pulse is of sufficient amplitude, the loop gain becomes greater than one, and the binary is triggered to its other stable state, V1 conducting the V2 cut off. The next input pulse reverses the process and causes the binary to return to its original state. Thus, the binary completes a cycle for every two input triggers, and is a scale of two. By a cascade arrangement of binaries, a counter having a scale of any power of two can be obtained.

Circuit Analysis

Four binaries are connected in cascade forming a scale of 16, which is permuted to a scale of 10 by two resistor-capacitor "feedback" networks (see Figure 3).

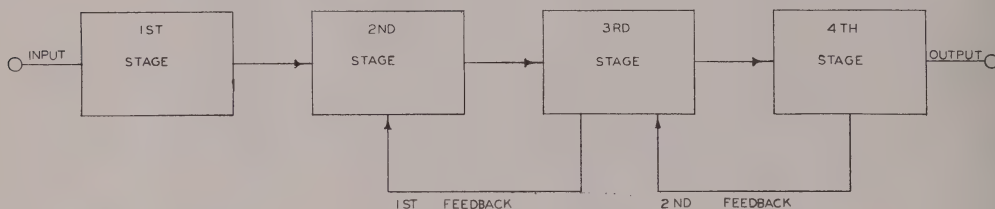


Figure 3
Functional Diagram, Model 705A

The circuit operates as a conventional binary counter up to the count of four. On the count of four the third stage is triggered, sending a pulse through the first feedback network, thereby triggering the second stage. Since it requires two inputs to trigger the second stage, this is the equivalent of adding two input pulses and the unit now corresponds to a

binary count of six. On the count of six (which is the equivalent of eight in a binary counter) the fourth stage is triggered, sending a pulse through the second "feedback" network and triggering the third stage. This is the same result as if four additional input pulses had been applied and the unit has a binary count of twelve stored in it. The unit again operates as a binary scaler for the remaining four pulses required to reset it to zero. Therefore, by adding the equivalent of six input pulses, the scale-of-16 has been permuted into a scale-of-10.

Section 4

MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Diagrams and Tables

Typical waveforms are shown in Figure 4. By comparing these with the waveforms from a defective unit, the faulty stage can be quickly detected. Table 2 lists the voltages and resistances between tube socket connections and ground so that, in conjunction with the schematics and parts location diagrams, all information necessary to maintain the equipment in proper working order is available. It should be remembered that the values given are nominal, and considerable variations may be encountered owing to various line voltage conditions and component tolerances.

Circuit drawings and parts location diagrams will be found at the rear of the manual. The voltages shown were obtained with a vacuum tube voltmeter, a supply voltage of 300 volts, and measured between ground and the point indicated. The unit must be reset to zero to obtain the values shown.

Table 1
COMMON TROUBLES*

<u>SYMPTOM</u>	<u>CAUSE</u>
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Stray output signal. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.
Unit Counts in Wrong Sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number.	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable states per cycle.	(a) Second stage defective (count can be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (count can be 0123 or 6789). (b) Loss of drive to third stage (0123).

4. Six stable states per cycle.

- (a) Output excessively loaded
(count can be 012345-012345).
(b) Last stage inoperative (count
can be
01234501 etc, or $67\frac{89}{23}89$. The

count $\frac{8}{2}$ indicates both "8" and
"2" lamps are on.

- (c) Loss of drive to fourth stage
(count can be 012345).

5. Eight stable states per cycle
or any failure where two
successive numbers are
skipped .

- (a) Second or third stage failure

6. Ten stable states per cycle,
but the lighting sequence is
incorrect.

- (a) Where the "0" neon lamp lights
instead of the "4", the trouble
is with either the "0" or "4"
lamp, and in the majority of
cases it is "4". This can
happen on any count; zero and
four were used as examples.
It is also possible that more
than one lamp may light in place
of or with the one that fails.

7. Twelve stable states per cycle.

- (a) When lighting sequence is
01 0
012345456789-0, etc. (The count 4
indicates both "0" and "4" lamps are
on.)

First feedback failure.

Second or third stage losing
emission.

- (b) When the lighting sequence is
23

012345678989-0, etc.

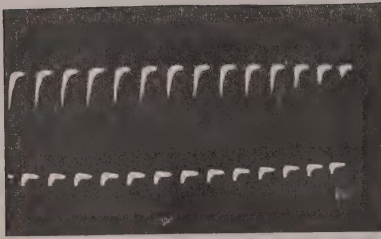
Second feedback failure.

Third or fourth stage losing
emission.

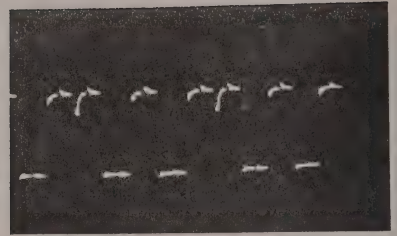
* Reset Unit before troubleshooting.

Table 2
MODEL 705A - VOLTAGES & RESISTANCES

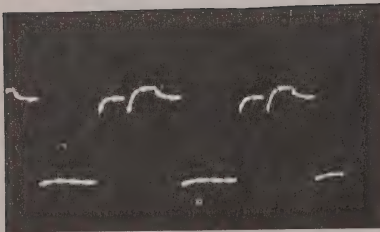
<u>Tube</u>	<u>Pin No.</u>	<u>D. C. Voltage to Ground</u>	<u>Resistance to Ground (in ohms)</u>
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K



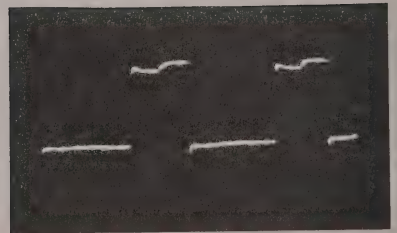
A. First Stage, Pin 6, V101, UVL + 168,
LVL + 58, frequency 20Kc.



B. Second Stage, Pin 6, V102, UVL + 140,
LVL + 55, frequency 20 Kc.



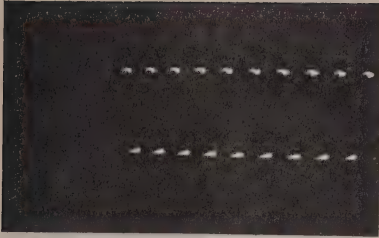
C. Third Stage, Pin 6, V103, UVL + 140,
LVL + 55, frequency 20 Kc.



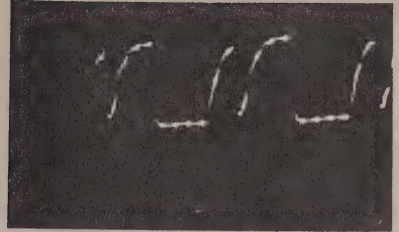
D. Fourth Stage, Pin 6, V104, UVL + 140,
LVL + 55, frequency 20Kc.

Note: UVL = upper voltage level
LVL = lower voltage level
All waveforms are blanked.

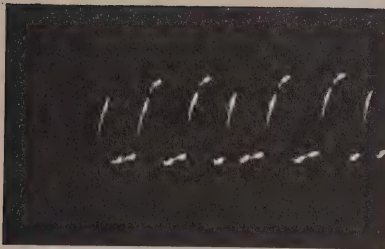
Figure 4 Typical Waveshapes



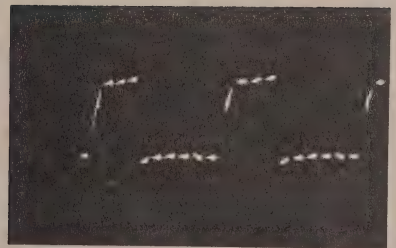
E. First Stage, Pin 6, V101, UVL + 168,
LVL + 58, frequency 100Kc.



F. Second Stage, Pin 6, V102, UVL 140,
LVL + 55, frequency 100Kc.

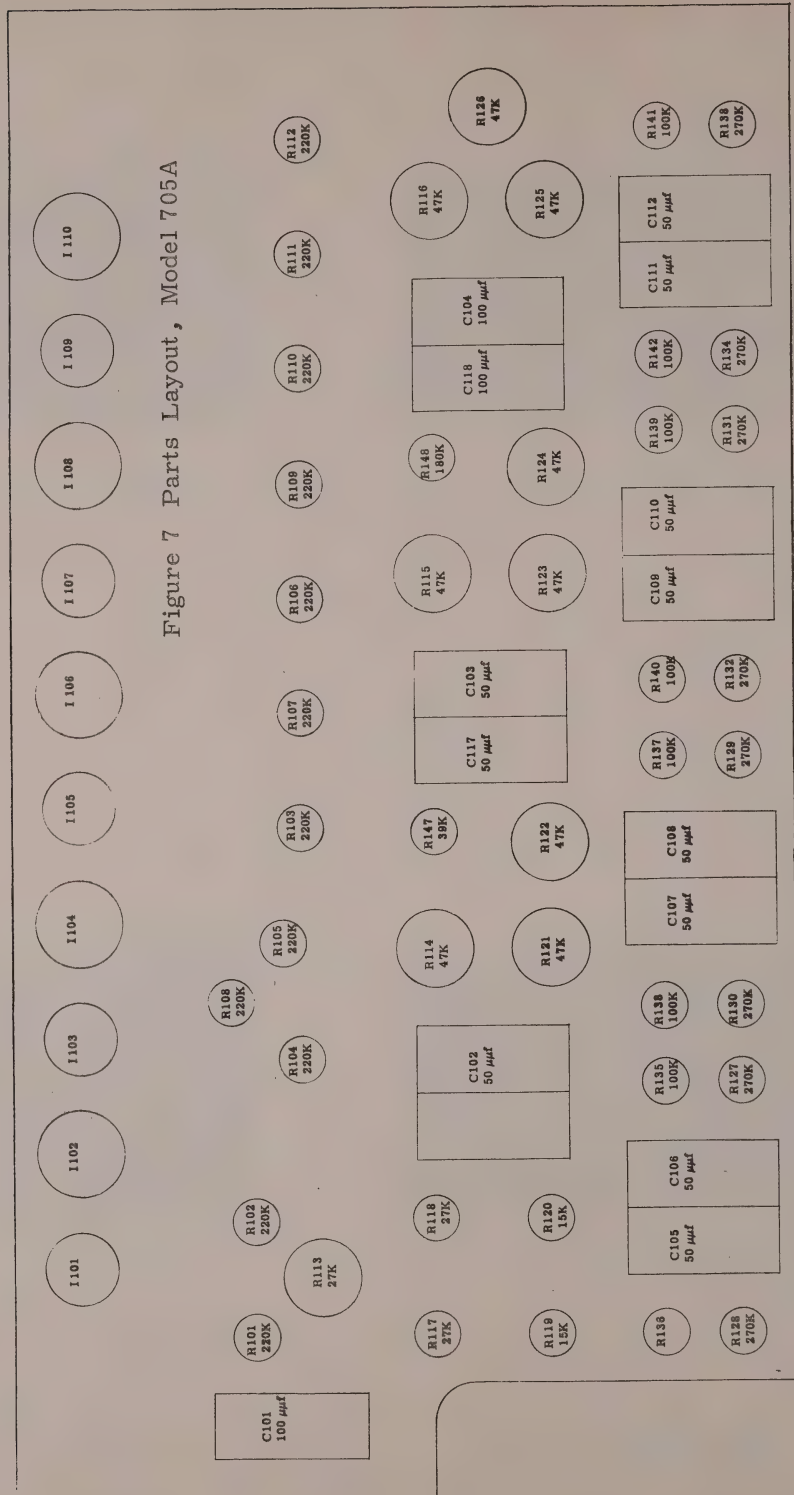


G. Third Stage, Pin 6, V103, UVL + 140,
LVL + 55, frequency 100Kc.



H. Fourth Stage, Pin 6, V104, UVL + 140,
LVL + 55, frequency 100 Kc.

Figure 7 Parts Layout, Model 705A



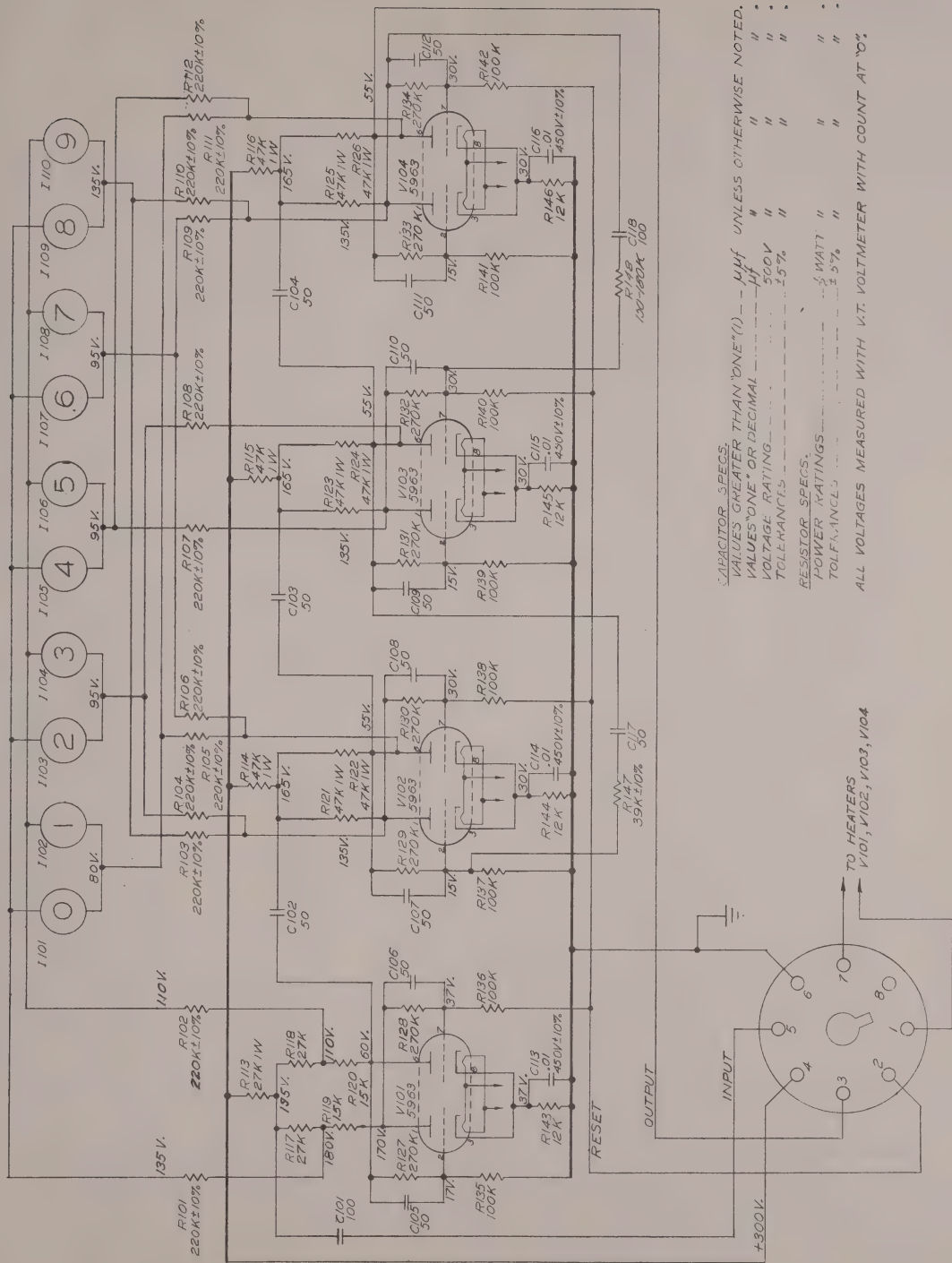


Figure 6 Schematic Diagram Model 705A

Model 707A
DECIMAL COUNTING UNIT

CONTENTS

Section 1	Introduction Description Specifications	1
Section 2	Operation Installation Operation	3
Section 3	Theory of Operation Basic Design Circuit Analysis	4
Section 4	Maintenance Routine Servicing Troubleshooting	6

ILLUSTRATIONS

Figure 1	Model 707A, Decimal Counting Unit	Frontispiece
Figure 2	Basic Circuit	4
Figure 3	Functional Diagram	5
Figure 4	Typical Waveshapes, Model 707A	10
Figure 5	Parts Layout, Model 707A	13
Figure 6	Schematic Diagram, Model 707A	15

